FINAL REPORT

Bio-Optical Studies in Support of the Coordinated Eastern Arctic Experiment (CEAREX)

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Publications by the PI contributing to understanding ocean optics as described in Figure 1. Citations with a double asterisk (**) were sponsored by grant N00014-89-J-1639; those with a single asterisk (*) were sponsored by ONR support since 1982.

* Carder, K. L., S. K. Hawes, K. A. Baker, R. C. Smith, R. G. Steward, B. G. Mitchell (1991) Reflectance model for quantifying chlorophyll a in the presence of productivity degradation products. Journal of Geophysical Research, 96(C11):20,599-20611.

** Cota, G. F, G. G. Mitchell, W. O. Smith, Jr. (1992) Photophysiology of *Phaeocystis pouchetti* in the Greenland Sea. In preparation.

* Iturriaga, R., B. G. Mitchell, D. A. Kiefer. 1988. Microphotometric analysis of individual particle absorption spectra. Limnology and Oceanography, 33(1):128-135.

Kiefer D. A. and B. G. Mitchell (1983) A simple, steady state description of phytoplankton growth based on absorption cross section and quantum efficiency. Limnology and Oceanography, 28, 770-776.

* Mitchell, B. G. and D. A. Kiefer (1984) Determination of absorption and fluorescence excitation spectra for phytoplankton. In Marine Phytoplankton and Productivity, O. Holm-Hansen, L. Bolis, and R. Gilles, Eds. Springer-Verlag, Berlin.

* Mitchell, B.G., R. Iturriaga, and D.A. Kiefer, 1984, Variability of spectral absorption coefficients in the Eastern Pacific Ocean. In Ocean Optics VII, Marvin Blizard, ed. Proc. Soc. Photo-Optical Instrumentation Engineers. 489: 113-118.

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** Mitchell, B. G. (1992) Predictive bio-optical relationships for polar oceans and marginal ice zones. Journal of Marine Systems. In press.

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Mitchell, B. G. and O. Holm-Hansen (1991b) Observations and modeling of the Antarctic phytoplankton crop in relation to mixing depth. Deep-Sea Research, 38(8/9): 981-1007.

** Mitchell, B. G., E. B. Brody, E-N. Yeh, C. McClain, J. Comiso and N. G. Maynard (1991) Meridional zonation of the Barents Sea ecosystem inferred from satellite remote sensing and in situ bio-optical observations. Polar Research. In press.

* Siegel, D. A., T. D. Dickey, L. Washburn, M. K. Hamilton and B. G. Mitchell (1989) Optical determination of particulate abundance and production variations in the oligotrophic ocean. Deep-Sea Research, 36:211-222.

* Sosik, H. M. and B. G. Mitchell (1991) Absorption, fluorescence, and quantum yield for growth in nitrogen-limited Dunaliella tertiolecta. Limnology and Oceanography, 326(5):910-922.

* Stramski, D. C., R. Booth and B. G. Mitchell (1992) Estimation of downward irradiance attenuation from a single moored instrument. Deep-Sea Research. In press.

** Tanis, F., T. O. Manley and B. G. Mitchell (1990) Helicopter and ship-based measurements of mesoscale ocean color and thermal features in the marginal ice zone. Ocean Optics X. R. Spinrad, Ed. SPIE 1302:225-237.

Wassmann, P., M. Vernet, B. G. Mitchell and F. Rey (1990) Mass sedimentation of Phaeocystis pouchetti in the Barents Sea. Marine Ecology Progress Series, 63:183-195.

Overview of ONR sponsored research to Dr. B. Greg Mitchell, and long-range goals

A thorough understanding of marine optics is a mission of significant Naval relevance. The ability to use optical measurements (in situ and remote) to estimate light propagation and phytoplankton growth rates is a significant objective. This objective requires a detailed understanding of the nature and variability of source and loss terms, and an ability to model the relevant rates. Figure 1 summarizes dominant state variables and transformations occurring in marine optics, and the contributions by the principal investigator in understanding these processes. Several significant problems previously have not been resolved with respect to measuring or modeling the processes in Figure 1. The long-range objectives of the principal investigator is to continue studies of the various components and rate processes shown in Figure 1 in an effort to improve our understanding of marine optical properties and photo-physiology and ecology of phytoplankton.

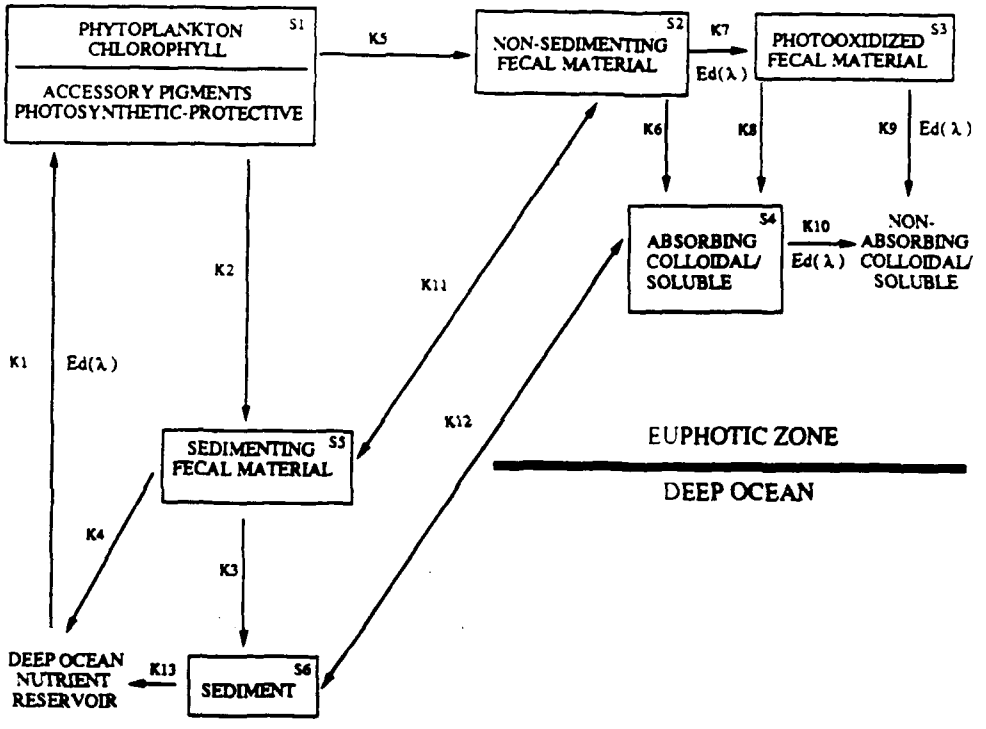

Figure 1. A conceptual model of optically important processes in the ocean. The long-range objectives of our research include a detailed understanding of the processes and state variables specified in this figure. The state variables in the boxes (S1-S6) correspond to dominant sources of optical variability in the oceans. The principal investigator has dedicated his research effort to understanding the diverse aspects of this system. Methods for estimating the magnitude and characteristics of S1, S2 and S3 have included analysis of particle absorption using microphotometry (Iturriaga et al., 1988); macrophotometry (Mitchell and Kiefer, 1984; Mitchell et al. 1984; Mitchell and Kiefer, 1988a; 1988b; Mitchell, 1990); in situ optical profiling resulting in discovery of regional bio-optical relationships (Mitchell and Holm-Hansen, 1991a; Mitchell, 1992); a novel method to estimate S1 from moored radiometers (Stramski et al. 1992); and aircraft (Tanis et al., 1990) or satellite observations of biomass (Mitchell et al., 1991). Optical based models of phytoplankton photosynthesis for laboratory cultures (Kiefer and Mitchell, 1983; Sosik and Mitchell, 1991) for Antarctic phytoplankton (Mitchell and Holm-Hansen, 1991b) and for Arctic phytoplankton (Cota et al., 1992) have been developed to model process K1. Siegel et al. (1989) used an *in situ* optical approach to estimate K1 and K2+K5 for populations in the North Pacific Gyre. Carder et al. (1991) have used optical methods to partition S1 from S2 and S3 for remote sensing. Sedimentation rates of Antarctic and Arctic phytoplankton (K2) have been studied by Mitchell and Holm-Hansen (1991b) and Wassman et al., (1990).

OBJECTIVES FOR N00014-J-89-1639

The objectives of the work sponsored under ONR grant N000-89-J-1639 was to undertake a detailed study of the optical properties of the Fram Strait during the CEAREX bio-optical-physical cruise. We sought to characterize S1+S2+S3 in Figure 1 using particulate and *in situ* optical methods. Optical models for defining process K1 are in development with other PI's in the program. We also were responsible for integrating the data from all investigators on the cruise and producing a database for publication as part of the CEAREX CD-ROM.

TASKS COMPLETED

A detailed study of the bio-optical properties of the Fram Strait during the spring bloom was made during April and May, 1989. Sixty profiles were made using a multi-channel bio-optical-physical profiling system. We flew 12 hours with a helicopter remote sensing system (HELOPS) when the participant from ERIM had to leave the ship mid-way through the cruise. During these flights, meso-scale features were identified and studied in detail.

Analysis of the data has been completed and all data from the various investigators has been released as a data report (Mitchell et al., 1991). The data report was submitted to the National Satelite Ice Data Center for inclusion in the CD-ROM of CEAREX data.

ACCOMPLISMENTS

Specific accomplishments included development of bio-optical models for remote sensing of phytoplankton pigments (Mitchell, 1991); studies of photoadaptation and photosynthetic modeling of *Phaeocystis pouchetti*, the dominant phytoplankton during the cruise (Cota et al., 1991); and remote sensing of ocean color and thermal features from a helicopter-borne system (Tanis et al., 1990a; 1990b). A comparison of satellite observations of sea ice and ocean color features for the Barents Sea was also accomplished. The results of much of this work is published or will be submitted soon. Collaborations are underway with CEAREX investigators on an optical-based model of primary production; a multi-variate model of bioluminescence; and a model of phytoplankton absorption for mixed layer heating during blooms.

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Mitchell, B. G., B. D. Schieber, E. A. Brody, E. J. Buskey, K. Davidson, L. A. Codispoti, T. Manley, D. Nelson, H. J. Niebaure and W. O. Smith, Jr. 1991. Coordinated Eastern Arctic Experiment (CEAREX): Biological-Physical-Optical Cruise Data Report April 10 - May 17, 1989. NSIDC CD-ROM publication of CEAREX data.

Tanis, F. J., T. O. Manley, B. G. Mitchell. 1990. Helicopter and ship-based measurements of mesoscale ocean color and thermal features in the marginal ice zone. Ocean Optics X. SPIE 1302:225-237.